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Capital Accumulation, Inflation
and Long-run Conflict in
International Objectives

by
F. van der Ploeg

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no. 37



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CAPITAL ACCUMULATION, INFLATION AND LONG-RUN CONFLICT IN INTERNATIONAL OBJECTIVES

By F. VAN DER PLOEG*

1. Introduction

THIS paper is concerned with the issue of whether policy objectives in an interdependent world are better achieved when governments cooperate than when national decisions are arrived at in a competitive fashion. The layman might take for granted that cooperation between governments would definitely make things better than they otherwise could be. However, most of the theoretical and empirical findings presented in the macroeconomic literature have hardly supported the layman's view. For example, Carlozzi and Taylor (1985) show that the gains from concerted government actions are negligible in an empirical study based on a two-country model where capital is perfectly mobile, exchange rates are flexible and labour markets behave according to the staggered wage-setting hypothesis (Taylor, 1979, 1980). In such a model long-run output is at its full-employment level and cannot be affected by government policy, although there is a long-run trade-off between the variances of output and prices. Carlozzi and Taylor (1985) find that individual governments can achieve the optimal trade-off between the asymptotic variability of output and prices just as well by choosing their own monetary rules as by cooperation.

A similar conclusion is reached by Miller and Salmon (1985) in a two-country model where output is demand-determined in the short run and where there is risk-neutral arbitrage between domestic and foreign government bonds. In this study there is no long-run conflict between the level of output (given by a vertical Phillips-curve in the long run) and inflation either. A flexible exchange rate allows each country to choose independently the desired rate of change in the domestic price level. Each country minimises a welfare function, which is the integral of a weighted combination of the square of core inflation and squared deviations of output from its natural rate. Again, no long-run gains from coordination are found, so that coordination is concerned with the efficient adjustment towards given long-run targets. The same problem is discussed in the work of Currie and Levine (1985) and Oudiz and Sachs (1985). All these studies are based on "neo-Keynesian" models, where the level of activity is

* The original idea for the problem discussed in this paper arose out of a number of stimulating discussions with my friend and colleague, Giancarlo Marini. I am very grateful to him for these discussions and constructive comments on this paper. The paper has also benefited from the extremely detailed and constructive comments of the anonymous referees and from seminar participants at the Macroeconomic Workshop, Paris; Helsinki University; Birkbeck College and Warwick University. Obviously, I take full responsibility for all errors and omissions. This paper is based on research funded by the Economic and Social Research Council (UK) and the Centre for Economic Policy Research, London.

affected by monetary shocks in the adjustment to equilibrium, even though the long-run equilibrium level of output itself is given and cannot be affected by current, past or prospective future policy actions. One typically finds that non-cooperative policy formulation leads to too tight monetary policy and to too loose fiscal policy in the process of adjustment, so that non-cooperative disinflation occurs excessively fast.

Similar conclusions about the desirability of coordinated policies have been obtained in flexible price, rational expectations models with pre-negotiated nominal wages. An example is given by Buiter and Eaton (1985), who show that the Nash solution is optimal when the objective in each country is minimising fluctuations of actual output around its *ex-ante* or *ex-post* natural level. They also point out that gains from policy coordination can only arise when the number of policy targets exceeds the number of policy instruments. This means that in models where there is no long-run trade-off between output and inflation, the analysis may as well (as in Buiter and Eaton, 1985) be confined to one objective at a time, say the minimisation of fluctuations of output around its *ex-post* frictionless level. In fact, if the only problem is due to the fact that spot labour contracts are not executable, the above criterion appears to be the most sensible one to adopt. A convincing welfare-theoretical rationale for this view has recently been provided by Aizenman and Frenkel (1985).

The purpose of the present paper is to investigate whether substantial gains from cooperation might arise in the presence of a genuine long-run inflation-output trade-off (when governments can pre-commit themselves to their announced policies). Under conditions of complete debt neutrality, capital accumulation and money bearing no rate of interest there is, as in the case of a closed economy (e.g. Tobin, 1965; Fischer, 1979; Begg, 1980; Buiter, 1981), a genuine long-run trade-off between inflation and output. This trade-off is based on a two-country version of the Mundell-Tobin effect. It is assumed that neither country likes inflation; the rationale for the costs of inflation are the usual ones presented in the literature (e.g. Fischer and Modigliani, 1978). Both countries, however, desire high levels of activity. The interesting feature of such a two-country model is that high inflation in one country leads to a reduction in the world real interest rate and therefore to higher output in both countries. This means that there is an incentive to transfer the burden of bearing high inflation to the neighbouring country. Here the case for cooperation becomes much stronger and is also relevant in the long run, for if both countries are prepared to live with higher anticipated inflation rates a mutual higher level of activity and of economic welfare could be achieved.

However, this unambiguous policy prescription may not be robust with respect to plausible changes in the specification of the model. Retaining the assumption of full price flexibility, a "Keynesian" flavour can be introduced by rejecting Barro's (1974) ultra-rational Ricardian hypothesis and therefore allowing bonds to be part of net wealth and consumption to be affected, to some extent, by disposable income. In other words, the restrictive hypothesis of perfect capital markets is relaxed so that private agents are unable to borrow

(against future life-time expected earnings) on the same terms as governments can do.¹ In such a context, lower monetary growth leads to less seignorage revenues and therefore forces the servicing of a smaller government debt, so that there is a possibility of lower wealth and consumption despite higher holdings of real money balances. Hence, there is a possibility that a reduction in inflation increases investment and output in the long run so that there is no policy dilemma. However, this possibility seems rather unlikely.

Section 2 sets up a perfect-foresight model of interdependent economies with capital accumulation, inflation and efficient exchange markets. Section 3 examines the long-run conflict in international objectives under the two alternative specifications discussed above. Section 4 presents a linearized version of the model of interdependent economies presented in Sections 2 and 3. Section 5 analyses the potential long-run gains from coordination by comparing various competitive and cooperative outcomes. It first considers the "rules" outcome where each government can pre-commit itself, *vis-à-vis* the private sector, to its announced present and future monetary policies. Here cooperation is unambiguously superior to competitive policy formulation, since coordination achieves a reduction in the world real rate of interest and an increase in global activity. However, this "rules" outcome suffers from time inconsistency as each government has an incentive to levy a "surprise" inflation tax on its private sector. Therefore Section 5 also considers credible or time-consistent monetary policies. It shows that the resulting "discretionary" outcomes for cooperation are no different from the time-consistent outcomes under competitive policy formulation and both lead to excessive monetary growth rates and higher levels of activity than under coordinated or competitive policy formulation with pre-commitment. Hence, in the absence of binding contracts or reputational forces, cooperation is futile. Section 6 concludes the paper.

2. Capital accumulation and inflation in interdependent economies

Consider two interdependent economies with a floating exchange rate and perfect capital mobility. There is imperfect substitution between home and foreign goods, although home and foreign government bonds are freely tradeable without cost and therefore perfect substitutes. Both labour and capital are immobile. Since this paper is mainly concerned with long-run conflict in international objectives, prices in both the goods and asset markets are assumed to be flexible and agents are assumed to have perfect foresight. All foreign variables and expressions are denoted by an asterisk.

Total demand in the home country, Y , consists of consumption of home goods by home, $C^D(\cdot)$, and foreign households, $C^{M*}(\cdot)$, and of gross investment. The

¹ An alternative formulation is based on private sector agents having, instead of infinite lives, a finite probability of death (Blanchard, 1985; Marini and van der Ploeg, 1988). However, note that Gale (1983) has shown that Ricardian equivalence can hold in disequilibrium Keynesian models.

IS-curve ignores the effects of the real rates of interest and is given by

$$Y = C^D(PY^D/P_C, \gamma, V) + \dot{K} + \delta K + C^{M*}(P^*Y^{D*}/P_C^*, \gamma, V^*),$$

$$C_i^D, C_i^{M*} \geq 0, \quad \forall i, \quad (2.1)$$

where Y^D , V , K , δ , γ , M , P and P_C denote disposable income, real wealth, capital, the depreciation rate, the real exchange rate, the nominal money supply, the price of home goods and the consumers' price index of the home country, respectively. Home consumption and exports of home goods increase when home real disposable income or wealth increases and when the real exchange rate depreciates. It is straightforward to allow for a negative effect of the home real interest rate on home consumption and of the foreign real interest rate on exports, but this does not affect the qualitative properties of the reduced form and is therefore ignored. Goods market equilibrium is given by

$$Y = f(K, N) \quad (2.2)$$

where the supply of goods follows from a concave constant-returns-to-scale production function, $f(K, N)$. The supply of labour abstracts from wealth and intertemporal substitution effects and is given by

$$N = N_S(w_C), \quad N'_S > 0, \quad (2.3)$$

where w_C is the real consumers' wage. The special case of an inelastic supply of labour corresponds to $N'_S = 0$. The demand for labour follows from $f_N = w$ and is given by

$$N = K n_D(w), \quad n'_D < 0, \quad (2.4)$$

where $w \equiv w_C P_C / P$ is the real producers' wage. The LM-curve is given by

$$M/P_C = L(PY/P_C, r) = L(Y, r)P/P_C, \quad L_Y > 0, \quad L_r < 0, \quad (2.5)$$

where r is the nominal rate of interest. The real demand for money increases when real income or the price of consols increases. It is assumed that $L(\cdot)$ is homogeneous of degree one with respect to its first argument.

The policy variable of each government is its monetary growth rate, $\mu \equiv \dot{M}/M$ or μ^* , which it can increase by purchasing consols. For simplicity, the effects of the government's fiscal policies are suppressed, so that the government's budget constraint can be written as

$$\mu M + \dot{B}/r = B, \quad (2.6)$$

where B is the number of outstanding bonds. The servicing of the government debt has to be financed, either by printing money or by issuing new bonds. It has been assumed that bonds are not necessarily part of private sector wealth, since financing of the public sector borrowing requirement by bonds may be perceived as an immediate reduction in disposable income by the discounted stream of future taxes required to service the increased government debt:

$$V = [PK + M + \alpha B/r]/P_C, \quad 0 \leq \alpha \leq 1, \quad (2.7)$$

where α is the extent to which government bonds are net wealth. It is assumed that changes in the stock of net foreign assets are a negligible proportion of changes in total financial wealth, so that the effects of current-account dynamics can be ignored.² With the aid of (2.6) disposable income can be defined as

$$Y^D \equiv Y + (B/P) - (1 - \alpha)(\dot{B}/rP) = Y + \alpha(B/P) + (1 - \alpha)\mu L, \quad L \equiv M/P, \quad (2.8)$$

so that an increase in the monetary growth rate implies less bond-finance, less future taxes and therefore a higher level of disposable income. The case $\alpha = 0$ corresponds to full debt-neutrality and relies on perfect capital markets and infinite lives or dynasties (e.g. Barro, 1974). In that case there are no liquidity constraints and thus $C_1^D = C_1^M = 0$ may be a reasonable assumption. The case $\alpha \neq 0$, $C_1^D \neq 0$ and $C_1^M \neq 0$ corresponds to when agents are not ultrarational or not altruistic or to when capital markets are imperfect.

The consumers' price index is given by

$$P_C = H(P, P^*E), \quad H_1, H_2 > 0, \quad (2.9)$$

where E is the nominal exchange rate and $H(\cdot)$ is homogeneous of degree one. The consumers' price index increases when the price of domestic or foreign goods increases. For example, a depreciation raises the price of imported goods and thus the consumers' price index. The demand for capital follows from the arbitrage condition

$$f_K(K, N) = r + \delta - \pi, \quad \pi \equiv (\dot{P}/P)^e, \quad (3.10)$$

which equates the marginal product of capital to its user cost (i.e. the rental plus depreciation charges, minus expected capital gains). Finally, the real exchange rate, $\gamma \equiv P^*E/P$, follows from the interest parity condition

$$r - \pi = r^* - \pi^* + (\dot{\gamma}/\gamma)^e. \quad (2.11)$$

Equation (2.11) says that the arbitrage actions of risk-neutral speculators ensure that the uncovered interest rate differential equals the expected rate of exchange depreciation. Forward integration yields

$$\gamma(t) = \gamma(\infty) \exp \left[- \int_t^\infty \{ (r(s, t) - \pi(s, t)) - (r^*(s, t) - \pi^*(s, t)) \} ds \right], \quad (2.12)$$

where $x(s, t)$ denotes the expectation of $x(s)$ formed at time t , hence the real exchange rate appreciates relative to its equilibrium value whenever the sum of all future expected real interest rate differentials in favour of the home country is positive.

The complete two-country model can be described by 21 equations, that is equations (2.1)–(2.11) and the foreign equivalents of equations (2.1)–(2.10). It corresponds to a two-country extension of previous models of closed economies

² Dornbusch and Fischer (1980) analyse the effects of current-account dynamics in a small open economy without capital accumulation.

with Mundell-Tobin effects, which were constructed to demonstrate the non-neutrality of anticipated demand-side policies (e.g. Fischer, 1979; Begg, 1980).

3. Long-run conflict in international objectives

Labour market equilibrium, $N_S(w_C) = Kn_D(w_C H(1, \gamma))$, gives $w_C = \bar{h}(K, \gamma)$, $\bar{h}_K = n_D/(N'_S - Kn'_D H) > 0$, $\bar{h}_\gamma = Kn'_D w_C H_\gamma / (N'_S - Kn'_D H) < 0$ so that employment is given by,

$$N = N_S(\bar{h}(K, \gamma)) \equiv h(K, \gamma), \quad h_j = N'_S \bar{h}_j, \quad j = K, \gamma \quad (3.1)$$

and aggregate supply by

$$Y = f(K, h(K, \gamma)) \equiv F(K, \gamma), \quad F_K = f_K + f_N h_K > 0, \quad F_{KK} < 0, \quad F_\gamma = f_N h_\gamma < 0, \quad (3.2)$$

where $f_{KK} + f_{KN} h_K < 0$ is assumed to hold for both countries.

Hence, an increase in the capital stock shifts out the labour demand schedule and therefore increases the real wage, equilibrium employment and aggregate supply. A depreciation of the real exchange rate increases the wedge between the producers' wage and the consumers' wage, so that employment and aggregate supply fall.

In the steady state, the real interest rates at home and abroad are equalised and the respective inflation rates are solely determined by domestic monetary growth rates. Hence, $r - \pi = r^* - \pi^*$, $\pi = \mu$, $\pi^* = \mu^*$ and $\dot{\gamma} = 0$. From (2.10) and (2.11), it follows that in long-run equilibrium

$$f_K(K, h(K, \gamma)) - \delta = f_{K^*}^*(K^*, h^*(K^*, 1/\gamma)) - \delta^* \quad (3.3)$$

and therefore

$$K^* = \psi(K, \gamma), \quad \psi_K = (f_{KK} + f_{KN} h_K) / (f_{K^*K^*}^* + f_{K^*N^*}^* h_{K^*}^*) > 0, \\ \psi_\gamma = \left(f_{KN} h_\gamma + f_{K^*N^*}^* h_\gamma^* \frac{1}{\gamma^2} \right) / (f_{K^*K^*}^* + f_{K^*N^*}^* h_{K^*}^*) > 0. \quad (3.4)$$

When the two economies are identical and have the same monetary growth rates, (3.4) yields $K^* = K$ in long-run equilibrium.

3.1. Bonds are not net wealth

Consider a world with perfect capital markets and infinitely-lived agents who perceive that a change in the holdings of bonds will eventually have to be matched by a future change in taxes of equal discounted value. In the absence of intertemporal borrowing constraints, the impact of current disposable income on consumption is negligible and can be ignored. When $\alpha = 0$, wealth consists

only of real money balances and capital, that is, $V = (PK + M)/P_C$. Hence, net investment can be written as

$$\begin{aligned} \dot{K} = & F(K, \gamma) - C^D(\cdot, \gamma, \{K + L[F(K, \gamma), f_K(K, h(K, \gamma)) + \pi - \delta]\}/H(1, \gamma)) \\ & - C^{M*}(\cdot, \gamma, \{K^* + L^*[F^*(K^*, \gamma^{-1}), f_K^*(K^*, h^*(K^*, \gamma^{-1})) \\ & \quad - (-) + \\ & \quad + \pi^* - \delta^*]\}/H^*(1, \gamma^{-1})) - \delta K \equiv I(K, K^*, \gamma, \pi, \pi^*), \end{aligned} \quad (3.5)$$

where the partial derivatives (evaluated at the steady state) are given by

$$I_K = r - \mu - C_V^D(1 + L_Y F_K + L_r \{f_{KK} + f_{KN} h_K\})H^{-1} + f_N h_K < 0,$$

$$I_{K^*} = -C_V^{M*}(1 + L_Y^* F_K^* + L_r^* \{f_{KK}^* + f_{KN}^* h_K^*\})H^{*-1} < 0,$$

$$\begin{aligned} I_Y = & F_Y - C_Y^D - C_V^D[L_Y F_Y + L_r f_{KN} h_Y - V H_Y]H^{-1} - C_Y^{M*} + C_V^{M*}[L_Y^* F_Y^* \\ & + L_r^* f_{KN}^* h_Y^* - V^* H_Y^*]H^{*-1}/\gamma^{*2} \quad (< 0), \end{aligned}$$

$$I_\pi = -C_V^D L_r H^{-1} > 0$$

and

$$I_{\pi^*} = -C_V^{M*} L_r^* H^{*-1} > 0.$$

The life-cycle hypothesis gives $C_V^D \approx r - \mu$, so that $I_K < 0$ as long as labour supply is not too elastic. Hence, the increase in output, caused by an increase in home capital, is outweighed by the increase in home consumption (due to higher wealth) and the increase in wear and tear, thus resulting in a reduction in net investment. Similarly, an increase in foreign capital boosts foreign wealth and therefore there is an increase in home exports and a corresponding fall in net home investment. A depreciation of the real exchange rate has four effects. The first is an increase in the home real consumers' price index, which causes a fall in home real wealth and thus a fall in home consumption and an increase in home investment. The second effect is a fall in the foreign real consumers' prices index, which causes an increase in foreign wealth and thus an increase in home exports and fall in home investment. The third effect is to increase the volume of home consumption and exports and thus to reduce net investment. The fourth effect is to increase the wedge between the producers' and consumers' wage, so that aggregate supply falls and therefore savings and net investment fall. The first and second effects cancel out in symmetric economies with $C_V^D = C_V^{M*}$, so that $I_Y < 0$. An increase in the home inflation rate increases the home nominal interest rate, so that agents economise on holdings of money balances, wealth and consumption fall, and thus net investment increases. An increase in the foreign inflation rate increases the foreign nominal interest rate, which reduces foreign wealth and home exports and thus increases net home investment.

Inflation is in the short run determined by (2.5), (2.10) and (3.2), $M/P = L[F(K, \gamma), f_K(K, h(K, \gamma)) + \pi - \delta]$, so that

$$\pi = \Pi \left(K, \frac{M}{P}, \gamma \right) \quad (3.6)$$

where

$$\Pi_K = -(L_\gamma F_K / L_r) - f_{KK} - f_{KN} h_K > 0,$$

$$\Pi_L = L_r^{-1} < 0,$$

and

$$\Pi_\gamma = -(L_\gamma F_\gamma / L_r) - f_{KN} h_\gamma \leq 0.$$

The partial derivative Π_K has been evaluated on the assumption that labour supply is not too elastic (small h_K, h_γ). A higher stock of money requires a lower interest rate and inflation rate in order to induce agents to willingly hold it. A higher capital stock increases income, reduces the real interest rate, and therefore increase money demand, which is choked off by higher inflation. A depreciation of the real exchange rate cuts income and reduces the real interest rate, so that the short-run effect on inflation is ambiguous. Obviously, inflation is in the long run determined by the monetary growth rate ($\pi = \mu$).

The steady-state effects of monetary growth on activity and the real exchange rate follow from:

$$I[K, \psi(K, \gamma), \gamma, \mu, \mu^*] = 0 \quad (3.7)$$

and

$$I^*[\psi(K, \gamma), K, 1/\gamma, \mu^*, \mu] = 0. \quad (3.8)$$

Figure 1 represents equations (3.7) and (3.8) as the zero-savings loci describing equilibrium in the home goods market (GME) and foreign goods market (GME*), respectively. The GME-locus slopes downwards, because the excess demand for home goods, induced by an increase in capital at home and abroad, is choked off by a fall in net exports and increase in aggregate supply, induced by an appreciation of the real exchange rate (and cut in the wedge between the producers' and consumers' wage). An increase in home (foreign) monetary growth increases inflation and reduces holdings of real money balances, wealth and consumption (exports). A real depreciation eliminates the incipient excess supply of goods, so that the GME-locus shifts upwards. Equilibrium at home and abroad yields

$$K = \bar{K}(\mu, \mu^*), N = \bar{N}(\mu, \mu^*), Y = \bar{Y}(\mu, \mu^*) \quad (3.9)$$

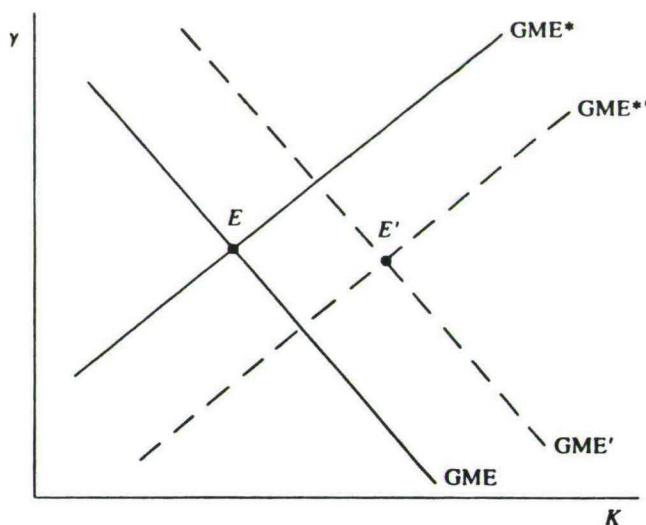


FIG. 1. Long-run effects of an increase in the home monetary growth rate in "ultrarational" interdependent economies.

and"

$$\gamma = \hat{\gamma} \begin{pmatrix} (+) \\ (-) \end{pmatrix} \begin{pmatrix} \mu \\ \mu^* \end{pmatrix}. \quad (3.10)$$

If the two economies are identical, the home and foreign monetary growth rates will be the same whether policies are coordinated or determined competitively (in Nash equilibrium) and therefore $K = K^*$ and $\gamma = 1$. It is clear that an increase in the home monetary growth rate leads to the same increase in home inflation, a reduction in the world real interest rate and therefore to an increase in both the home and foreign levels of capital, output and employment. This is the interdependent analogue of the Mundell-Tobin effect and explains that monetary expansion is a "locomotive" policy in the long run. In fact, foreign inflation is unaffected and therefore each country has an incentive to transfer the burden of reducing the world real interest rate to the other country.

3.2. Imperfect capital markets and selfishness

Now consider the situation where Barro-Ricardo debt neutrality does not hold and where there are liquidity constraints, hence $\alpha = 1$ and home consumption and exports of home goods depend to a certain extent on home and foreign disposable income, respectively. Manipulation of the government budget constraint, (2.6), and (2.7) yields long-run real wealth:³

$$V = [PK + (r/(r - \pi))M]/P_C. \quad (3.11)$$

³ In the long run $\dot{M}/M = \dot{B}/B = \mu$ so that (2.6) gives $B/M = r\mu/(r - \mu)$. Substitution into (2.7) gives (3.11).

An increase in inflation acts as a tax and therefore allows the servicing of a larger interest-bearing government debt, which boosts the real value of private sector wealth. Upon substitution of (2.5), (2.9), (2.10) and (3.2) into (3.11), one obtains the financial component of long-run real wealth:

$$\begin{aligned} V - (PK/P_C) &= L[F(K, \gamma)/H(1, \gamma), f_K + \mu - \delta](f_K + \mu - \delta)/(f_K - \delta) \\ &\quad + - ? \\ &\equiv V_F(K, \gamma, \mu), \quad V_F = [rL_r + (M/P_C)/(r - \mu)] \leq 0. \end{aligned} \quad (3.12)$$

An increase in the monetary growth rate increases long-run inflation, which increases the nominal interest rate and reduces the holdings of money balances. However, it also increases the revenue from the "inflation tax" and allows the servicing of a larger interest-bearing government debt. The net effect of inflation on financial wealth is therefore ambiguous. Note that, with full debt neutrality (see Section 3.1), inflation unambiguously decreases financial wealth in the long run.

Upon substitution of (2.9), (3.2), (3.12) and $B/P_C = \mu V_F$ into (2.1), one obtains the long-run expression:

$$\begin{aligned} \dot{K} &= F(K, \gamma) - \delta K - C^D[F(K, \gamma)/H(1, \gamma) + \mu V^F(K, \gamma, \mu), \gamma, KH(1, \gamma)^{-1} \\ &\quad + V^F(K, \gamma, \mu)] - C^{M*}[F^*(K^*, \gamma^{-1})/H^*(1, 1/\gamma) \\ &\quad + \mu^* V^{F*}(K^*, 1/\gamma, \mu^*), \gamma, K^* H^*(1, 1/\gamma)^{-1} + V^{F*}(K^*, 1/\gamma, \mu^*)] \\ &\quad (-) - (-) ? ? \\ &\equiv I(K, K^*, \gamma, \mu, \mu^*) = 0. \end{aligned} \quad (3.13)$$

One of the differences with Section 3.1 is that real income and interest payments now play a role in the consumption and export functions. This tends to accentuate the negative effects of an increase in home or foreign capital and a real depreciation on net investment. The main point is, however, that the long-run effects of the monetary growth rates on net investment are no longer unambiguous (as they were in (3.5)):

$$I_\mu = -C_V^D(V^F + \mu V_\mu^F) - C_V^D V_\mu^F \geq 0$$

and

$$I_{\mu^*} = -C_{V^*}^{M*}(V^{F*} + \mu^* V_{\mu^*}^{F*}) - C_{V^*}^{M*} V_{\mu^*}^{F*} \geq 0.$$

For example, if $V_\mu^F > 0$ and $V_{\mu^*}^{F*} > 0$, then $I_\mu < 0$ and $I_{\mu^*} < 0$ and therefore $\dot{K}_\mu < 0$ and $\dot{K}_{\mu^*} < 0$. It is therefore possible that, if the effects of the "inflation tax" on public sector debt are large enough, an increase in the monetary growth rate reduces both the home and foreign levels of capital, output and employment. In that case, monetary expansion is a "beggar-thy-neighbour" policy, but more importantly the long-run conflict between inflation and output or employment has disappeared. From a practical point of view, it seems unlikely that there is no conflict between inflation and activity. Nevertheless, the relaxation of debt neutrality does seem to improve the long-run inflation-output trade-off.

4. A linearized disequilibrium system of interdependent economies

It has been shown in Section 3 that a higher domestic monetary growth rate typically leads in the long run to increases in capital, output and employment. A linearized disequilibrium version of this result for symmetric interdependent economies with $C_V^D = C_V^M = r - \pi$ around $\mu = \mu^* = 0$ can be written as:⁴

$$\dot{k} = -\beta_1 k^* - \beta_2(l + l^*) - \beta_3 e, \quad k(0) = k_0, \quad (4.1)$$

$$\dot{k}^* = -\beta_1 k - \beta_2(l + l^*) + \beta_3 e, \quad k^*(0) = k_0^*, \quad (4.2)$$

$$\dot{l} = \mu - \pi = \mu - \beta_4 k + \beta_5 l - \beta_6 e, \quad l(0) = \text{free}, \quad (4.3)$$

$$\dot{l}^* = \mu^* - \pi^* = \mu^* - \beta_4 k^* + \beta_5 l^* + \beta_6 e, \quad l^*(0) = \text{free}, \quad (4.4)$$

and

$$\dot{e} = \beta_7(k^* - k) - \beta_8 e, \quad e(0) = \text{free}, \quad (4.5)$$

where $e \equiv \log(\gamma)$, k and $l \equiv \log(L) = \log(M/P)$ are expressed as the logarithmic deviations from the steady-state levels associated with zero inflation ($\mu = \mu^* = 0$), $\beta_1 \equiv C_V^M > 0$, $\beta_2 \equiv C_V^M L/K^* > 0$, $\beta_3 \equiv -(F_\gamma - C_V^D - C_V^M)\gamma/K > 0$, $\beta_4 \equiv K\Pi_K > 0$, $\beta_5 \equiv -L\Pi_L > 0$, $\beta_6 \equiv \gamma\Pi_\gamma \geq 0$, $\beta_7 \equiv -K(f_{KK} + f_{KN}h_K) > 0$ and $\beta_8 \equiv -2\gamma f_{KN}h_\gamma > 0$. The steady state is given by $\pi = \mu$, $\pi^* = \mu^*$, $e = 0$, $k = k^* = -\frac{1}{2}(\beta_2/\Delta)(\mu + \mu^*)$ and $l = [(\beta_1 + \frac{1}{2}\beta_2\beta_4/\beta_5)\mu - (\beta_2\beta_4/\beta_5)\mu^*]/\Delta$, where $\Delta \equiv -\beta_1\beta_5 - \beta_2\beta_4 < 0$. The normalisation $\beta_2 = -2\Delta$ is employed, so that in steady state $k = k^* = \mu + \mu^*$. Hence, in the steady state inflation is entirely a monetary phenomena, purchasing power parity holds and activity (the real interest rate) is, via the interdependent Mundell-Tobin effect, an increasing (decreasing) function of monetary growth at home and abroad. The steady-state level of real money balances decreases when home monetary growth increases and when foreign monetary growth decreases. It can be shown that, when $2\beta_3\beta_7 > \beta_1\beta_8$, the Jacobian of the system (4.1)–(4.5) satisfies the saddlepoint property, that is, it has two stable eigenvalues associated with the backward-looking (predetermined) variables, k and k^* , and three unstable eigenvalues associated with the forward-looking (jump) variables, l , l^* and e .

In fact, given that the two economies have an identical structure, it is possible to give a complete diagrammatic analysis in terms of global averages and differences (cf., Aoki, 1981). If average activity and average liquidity in the world economy are given by $k^a \equiv \frac{1}{2}(k + k^*)$ and $l^a \equiv \frac{1}{2}(l + l^*)$, one obtains the independent sub-system:

$$\begin{pmatrix} \dot{k}^a \\ \dot{l}^a \end{pmatrix} = \begin{pmatrix} -\beta_1 & -\beta_2 \\ -\beta_4 & \beta_5 \end{pmatrix} \begin{pmatrix} k^a \\ l^a \end{pmatrix} + \begin{pmatrix} 0 \\ \frac{1}{2} \end{pmatrix} (\mu + \mu^*). \quad (4.6)$$

⁴ Equations (4.1)–(4.2) follow from log-linearising $\dot{K} = F(K, \gamma) - C^D(\cdot, \gamma, (K+L)H^{-1}) - C^M(\cdot, \gamma, (K^*+L^*)H^{*-1}) - \delta K$, equations (4.3)–(4.4) from log-linearising (3.6), and equation (4.5) from $\dot{e} = f_K - f_K^*$.

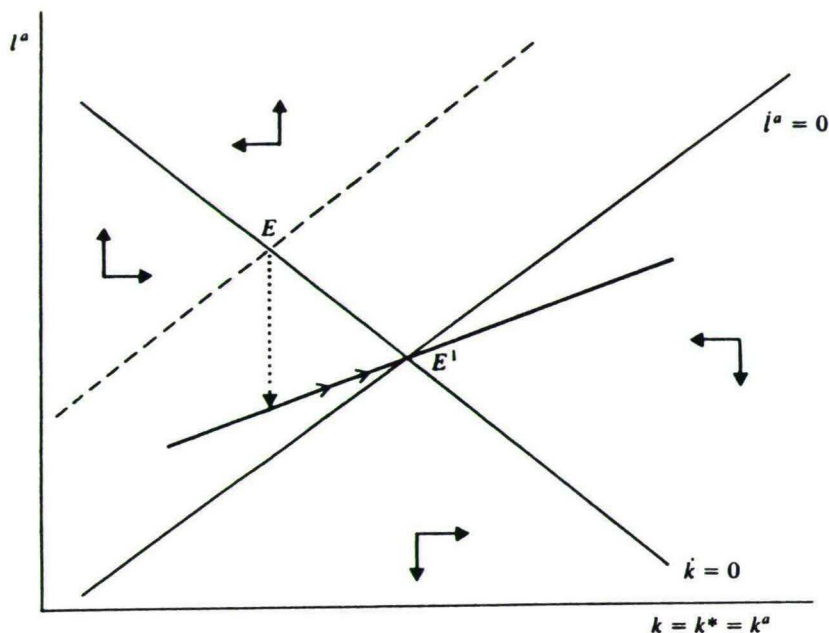


FIG. 2. Unanticipated increase in monetary growth in interdependent economies.

Similarly, if $k^d \equiv k - k^*$, one obtains the independent sub-system:

$$\begin{pmatrix} \dot{k}^d \\ \dot{e} \end{pmatrix} = \begin{pmatrix} -\beta_1 & -2\beta_3 \\ -\beta_7 & -\beta_8 \end{pmatrix} \begin{pmatrix} k^d \\ e \end{pmatrix}. \quad (4.7)$$

The determinants of the Jacobians of (4.6), $\Delta < 0$, and of (4.7), $\beta_1\beta_8 - 2\beta_3\beta_7 < 0$ (for not too elastic labour supply), are both negative, so that the equilibria of the two sub-systems are saddlepoints.⁵ This corresponds to the forward-looking behaviour of l^a , l^d and e and to the backward-looking behaviour of k^a and k^d .

Since there are no shocks that give rise to relative demand shifts, (4.7) shows that $k^d = e = 0$ must hold all the time. It follows that $k = k^* = k^a$, $l = l^a + \frac{1}{2}l^d$, $l^* = l^a - \frac{1}{2}l^d$, $\pi = \beta_4 k - \beta_5 l$ and $\pi^* = \beta_4 k - \beta_5 l^*$, where k , l^a and $l^d \equiv l - l^*$ follow from the dynamics of (4.6) and

$$l^d = \mu^d + \beta_5 l^d, \quad l^d(0) = \text{free}. \quad (4.8)$$

Note that there is no exchange rate overshooting, because the goods and labour markets are assumed to clear instantaneously.

Figure 2 shows what happens if there is an unanticipated permanent increase in either the home or foreign monetary growth or in both. On impact global

⁵ The eigenvalues of the system (4.1)–(4.5) and of the systems (4.6), (4.7) and $l^d = \mu^d - \beta_4 k^d + \beta_5 l^d + 2\beta_6 e$ are exactly the same.

real liquidity jumps discretely downwards, overshooting its new equilibrium value, and afterwards gradually rises along the stable arm to the new equilibrium E^1 . Employment, output and capital (i.e. activity) do not change on impact, but afterwards gradually increase as the real interest rate falls.⁶ On impact, the difference in real liquidities, l^d , jumps immediately to $(\mu^* - \mu)/\beta_3$. Hence, a common increase in the monetary growth rates leads on impact to an upward jump in the common inflation rate which overshoots the higher equilibrium level. Also, an increase in the home monetary growth rate reduces home liquidity and increases foreign liquidity and therefore increases home inflation and reduces foreign inflation. The dynamic consequences of anticipated or temporary changes in the monetary growth rates can also be analysed in terms of averages and differences.

5. Gains from macroeconomic policy coordination: a long-run perspective

This section compares various cooperative and competitive outcomes. The welfare loss function of each government is quadratic and depends positively on activity and negatively on inflation:⁷

$$\text{Min}_\mu W = \int_0^\infty [\theta(k - \bar{k})^2 + \pi^2] \exp(-\rho t) dt, \quad \theta > 0, \quad \bar{k} > 0 \quad (5.1)$$

where \bar{k} and zero are the desired values for the two objectives of economic policy and ρ is the rate of time preference. The long-run conflict manifests itself in the target (or full-employment) level of the capital stock being inconsistent with no inflation. Note that the qualitative conclusions of the analysis are unaffected when the government also cares about the level of national income and/or employment, as both of these are positively correlated with output. The individual governments minimise (5.1) subject to the system (4.1)–(4.5). Discounting is introduced to ensure that the welfare loss function converges, but to keep matters simple results are presented for the case where the discount rate is arbitrarily small. This does not affect the qualitative nature of the results. Section 5.1 considers the steady state of various cooperative and competitive differential-game outcomes when each government can pre-commit itself to its announcements about present and future monetary policies. The Appendix shows that, when $\rho \rightarrow 0$, those steady-state outcomes with pre-commitment can also be obtained from minimising the asymptotic welfare loss function, $\theta(k - \bar{k})^2 + \mu^2$ for the home government and $\theta(k^* - \bar{k})^2 + \mu^{*2}$ for the foreign government, subject to the steady-state constraint, $k = k^* = \mu + \mu^*$. The Appendix also considers the disequilibrium features of the optimal strategies. Section 5.2 uses differential game theory to analyse the intertemporal trade-offs

⁶ The speed at which activity moves towards the new equilibrium is given by $\frac{1}{2}(\beta_3 - \beta_1) - \frac{1}{2}\sqrt{(\beta_3 - \beta_1)^2 - \Delta}$.

⁷ The effects of a more general welfare loss function, which depends on aggregate consumption and therefore on income (capital), liquidity and monetary growth, is discussed in Section 5.2.

and demonstrates that the non-cooperative outcomes of Section 5.1 are time inconsistent. Section 5.2 also discusses credible solution concepts for competitive decision making in interdependent dynamic economies with perfect foresight.

5.1. Asymptotic cooperative and competitive outcomes under pre-commitment

In the Nash equilibrium each country takes the policies of the other country as given, which yields the asymptotic reaction curve

$$\mu = \theta(\bar{k} - \mu^*)/(1 + \theta). \quad (5.2)$$

When the rival country increases its monetary growth rate, home output increases yet home inflation is unaffected. This diminishes the marginal welfare of income, so that the home government shifts its attention towards the inflation target and thus reduces its monetary growth rate. The intersection of the home and foreign reaction curve yields, for the case $\bar{k} = \bar{k}^*$, the asymptotic symmetric Nash equilibrium solution:

$$\mu = \mu^* = \mu_N \equiv \theta\bar{k}/(1 + 2\theta). \quad (5.3)$$

Obviously, when the priority attached to improving capital, output or employment (θ) increases, the governments end up with higher inflation rates.

An alternative solution concept for competitive policy formulation is the Stackelberg equilibrium solution. If the foreign country is the leader, it minimises its welfare loss function subject to the follower's reaction curve, (5.2). This yields the leader's asymptotic monetary growth rate,

$$\mu^* = \mu_s^* \equiv \theta\bar{k}/(1 + 3\theta + \theta^2) < \mu_N, \quad (5.4)$$

and the follower's asymptotic monetary growth rate,

$$\mu = \mu_s \equiv \theta(1 + \theta)\bar{k}/(1 + 3\theta + \theta^2) > \mu_N > \mu_s^*. \quad (5.5)$$

The leader has managed to transfer some of the burden of lowering the world real interest rate to the follower, which makes the leader better off and the follower worse off than in the Nash equilibrium solution.⁸ Note that both countries also end up with lower levels of capital, output and employment than in the Nash equilibrium solution.

When the two countries coordinate their monetary policies, they might minimize the global welfare loss:

$$\text{Min}_{\mu, \mu^*} W + W^* = \int_0^{\infty} [\theta(k - \bar{k})^2 + \theta(k^* - \bar{k}^*)^2 + \pi^2 + \pi^{*2}] \exp(-\rho t) dt, \quad (5.6)$$

⁸ The follower is worse off, because it ends up with higher inflation and lower output, $k = k^* = \theta\bar{k}(2 + \theta)/(1 + 3\theta + \theta^2) < 2\mu$, than in the Nash case.

which, in the absence of asymmetric preferences, yields the Nash bargaining solution. This yields the asymptotic cooperative monetary growth rates,

$$\mu = \mu^* = \mu_C \equiv 2\theta\bar{k}/(1 + 4\theta) > \mu_s > \mu_N > \mu_s^*, \quad (5.7)$$

so that coordination leads to a joint expansion of monetary growth rates. The reason for this is that with cooperation there is no longer an incentive to transfer the burden of bearing high inflation to the rival country. The steady-state level of activity under coordination ($k = k^* = k_C$) exceeds the level of activity under Nash-competition ($k = k^* = k_N$), which exceeds the level of activity under Stackelberg-competition ($k = k^* = k_s \equiv \mu_s + \mu_s^*$): $k_C > k_N > k_s$. The cooperative outcome is not sustainable without some form of commitment, since each country has an incentive to deviate. If the home country cheats, it chooses to reduce its monetary growth.

$$\mu_s^* < \mu = \mu_D \equiv \theta(1 + 2\theta)\bar{k}/(1 + 4\theta)(1 + \theta) < \mu_N, \quad (5.8)$$

in order to reap the benefits of a relatively low world real rate of interest without suffering from high inflation. The various cooperative and competitive outcomes are portrayed in Figure 3.

It can be shown that the percentage reduction in welfare loss obtained from international policy coordination is $100 \theta / [(1 + \theta)(1 + 4\theta)]$, which corresponds to 7.4%, 10%, 11.1% and 10% for $\theta = 2, 1, \frac{1}{2}$ and $\frac{1}{4}$. These are substantial gains from coordination, since they last forever. The corresponding gains in previous studies are zero (e.g., Currie and Levine, 1985; Miller and Salmon, 1985; Oudiz and Sachs, 1985; Rogoff, 1985), since these studies only considered transient trade-offs.

If, however, one country (say, the foreign country) were interested in a relatively higher level of national activity ($k^* > \bar{k}$), one obtains

$$\mu = \mu^* = \mu_C \equiv \theta(\bar{k} + k^*)/(1 + 4\theta) \quad (5.9)$$

under coordination or

$$\mu = \mu_N \equiv \theta[\bar{k} + \theta(\bar{k} - k^*)]/(1 + 2\theta) \quad (5.10)$$

and

$$\mu^* = \mu_N^* = \theta[k^* + \theta(k^* - \bar{k})]/(1 + 2\theta) > \mu_N \quad (5.11)$$

under competitive (Nash) policy formulation. The foreign country engages in a more inflationary strategy, since it cares more for a higher level of activity. The home country benefits from the reduction in the world real interest rate and can therefore afford to pursue a less inflationary strategy.

5.2. Credibility and coordination

The problem with decentralised international policy formulation with pre-commitment, as discussed in Section 5.1, is that it is time inconsistent, since each government has an incentive to revise and re-optimize its announced optimal monetary policies after some time. This time inconsistency refers to the

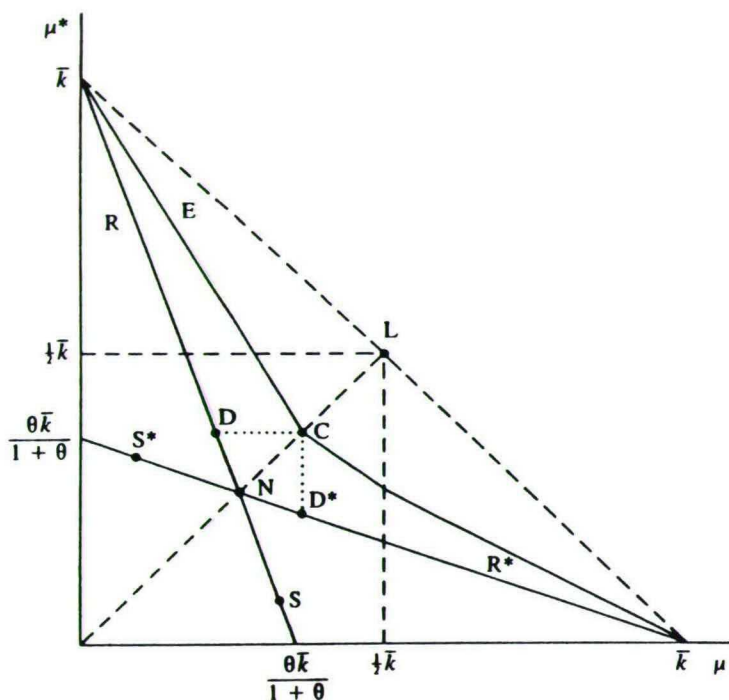


FIG. 3. Cooperative and competitive monetary policies under pre-commitment.

- Key: R—Reaction curve of home country
 N—Nash equilibrium
 S—Stackelberg equilibrium (if the home country follows)
 E—Efficient outcomes
 C—Cooperative (Nash bargaining) outcome
 D—Deviation of the home country from the cooperative outcome
 D*—Deviation of the foreign country from the cooperative outcome
 L—"Loss of leadership" solution

fact that it pays a government or Central Bank to renege on the promise it has made about its future monetary policies to the private sectors. It should be distinguished from when a government deviates from a cooperative agreement and *cheats on a rival government*. The time inconsistency also holds at the steady state of the pre-commitment non-cooperative outcomes, so that these outcomes are, in the absence of "binding contracts" or reputational forces, unattainable or not credible. This can be seen from the fact that the shadow prices of the forward-looking expectations variables, l^a and l^d ,⁹ are zero at the beginning of the planning period, as they are unconstrained by their past history at time zero and therefore their marginal contribution to economic welfare should be zero at that point of time, but they differ from zero after time zero (see Appendix). The intuition behind the time inconsistency of optimal monetary policy is that each government has an incentive to levy a "surprise" inflation

⁹ For the Stackelberg outcome with pre-commitment, the home country's shadowprice of activity is also a forward-looking variable as far as the foreign country is concerned (see Appendix).

tax and thereby erode the real value of money balances (cf., Calvo, 1978). The time inconsistency of the non-cooperative outcomes with pre-commitment raises welfare by a sufficient amount to ensure that all multilateral incentives to renege with a "surprise" inflation tax are eliminated (see Appendix), which can be seen from the fact that the shadowprices of the forward-looking variables, l^a and l^d , are always zero for this case. However, there is, of course, the usual unilateral incentive to deviate from the cooperative outcome (see equation (5.8)).

When neither government can pre-commit itself to its announced optimal monetary growth rates, time-consistent non-cooperative outcomes are relevant. Both the "loss of leadership" solution proposed by Buiter (1983) and the dynamic programming solution proposed by Cohen and Michel (1984)¹⁰ treat the forward-looking variables, l^a and l^d , as predetermined at the time of optimisation and, as the Appendix shows, lead to an infinite number of solutions. However, if the monetary growth rate enters the welfare loss function directly or indirectly, this indeterminacy can be resolved. For example, if each government wants to increase aggregate consumption and decrease inflation, the welfare loss criterion becomes, instead of (5.1):

$$\text{Min}_\mu W = \int_0^\infty [\theta(\theta_1 k + \theta_2 l + \theta_3 \mu - \bar{c})^2 + \pi^2] \exp(-\rho t) dt, \theta_1, \theta_2, \theta_3, \bar{c} > 0 \quad (5.12)$$

where \bar{c} denotes the desired value of aggregate consumption. The long-run conflict now manifests itself in the target level of aggregate consumption being inconsistent with no inflation. Consumption of home and foreign goods increases with wealth, so that it increases with capital (k) and holdings of real money balances (l). Consumption typically also depends on disposable income, so that it increases with production income (proxied by k) and, to the extent that public sector deficits are not financed by consols, the discounted stream of future inflation taxes diminishes (see equation (2.8)) and thus consumption increases with the monetary growth rate (μL). It is a straightforward exercise to show that, when $\bar{c} = \bar{c}^*$, the steady-state values of the monetary growth rates under international policy coordination with pre-commitment are

$$\mu = \mu^* = \mu_c \equiv \frac{\theta\theta_4\bar{c}}{1 + \theta\theta_4^2}, \quad \theta_4 \equiv 2\theta_1 + \theta_2\left(\frac{2\beta_4 - 1}{\beta_5}\right) + \theta_3 \quad (5.13)$$

and under decentralised formulation of national policies with pre-commitment are

$$\mu = \mu^* = \mu_N \equiv \frac{\theta\theta_5\bar{c}}{1 + \theta\theta_4\theta_5} < \mu_c, \quad 0 < \theta_5 \equiv \theta_1 + \theta_2\left(\frac{\beta_4 - 1}{\beta_5}\right) + \theta_3 < \theta_4. \quad (5.14)$$

¹⁰ The dynamic programming solution assumes that l^a and l^d are a linear function of the predetermined variable, k^* , as given by the stable manifold.

The steady-values of consumption are given by $\theta_4 \mu_C$ and $\theta_4 \mu_N$, respectively. Note that, when $\theta_1 = 1$, $\theta_2 = \theta_3 = 0$ and $\bar{c} = \bar{y}$, then $\theta_4 = 2$, $\theta_5 = 1$ and thus (5.13) and (5.14) reduce to (5.7) and (5.3). It is also clear that competitive policy formulation with pre-commitment leads to inefficiently low levels of monetary growth and activity. Coordination with pre-commitment is, for $\theta_3 \neq 0$, now time inconsistent, since the marginal value of global liquidity to the world planner is strictly negative and therefore there is an incentive to renege and impose a "surprise" inflation tax (see Appendix). Decentralised policy formulation is, as before, time inconsistent.

Now consider the credible outcomes. The "loss of leadership" solution recognises that the governments are unable to influence the expectations of the private sectors and therefore treats the forward-looking variables, l^a and l^d , as predetermined. It follows that the "loss of leadership" solution for both the cooperative and non-cooperative outcome lead to the following monetary growth rates (see Appendix):

$$\mu = \mu^* = \mu_L \equiv \bar{c}/\theta_4 > \mu_C > \mu_N. \quad (5.15)$$

Since the governments have lost their ability to make credible announcements about future monetary policy, the governments perceive that they cannot influence the inflation rates and therefore pursue a policy of exactly achieving the desired level of aggregate consumption. It follows that international cooperation is futile as the welfare loss is exactly the same as under the competitive (Nash and Stackelberg) outcomes, that is $W = W^* = W_L \equiv \bar{c}^2/\theta_4^2$.¹¹ There simply is no point in international policy coordination, because neither country has credibility and therefore each country is forced to set the level of activity to its desired level.

The asymptotic welfare loss under policy coordination with pre-commitment is given by

$$W = W^* = W_C \equiv \theta \bar{c}^2/(1 + \theta \theta_4^2) < W_L, \quad (5.16)$$

so that the world planner can obviously improve global welfare when it can establish binding contracts or a reputation for not renegeing with the private sectors. The welfare loss of competitive (Nash) policy formulation with pre-commitment is given by

$$W = W^* = W_N \equiv \theta(1 + \theta \theta_3^2) \bar{c}^2/(1 + \theta \theta_4 \theta_5)^2 \quad (5.17)$$

which is less than W_L if $1 + \theta \theta_4(\beta_3 \theta_3 - \theta_2)/\beta_3 > 0$ holds.

It may be that the foreign country cannot pre-commit and is therefore forced to use credible policies, $\mu^* = \mu_L$. If the home government can pre-commit then the steady-state outcome under decentralized policy formulation is given by

$$\mu = \mu_{NC} \equiv \theta \theta_3^2 \bar{c}/[\theta_4(1 + \theta \theta_3^2)] < \mu_N. \quad (5.18)$$

¹¹ Strictly speaking, the welfare losses for the case that $\rho \rightarrow 0$ do not converge and therefore cannot be evaluated. Hence, the welfare losses given are asymptotic averages over time.

Since the foreign government is forced to have an excessive monetary growth rate, it carries most of the burden of reducing the world real interest rate. It follows that the home country can reap the benefits in terms of higher activity and therefore engage in a less inflationary policy. Note that, if $1 + \theta\theta_4(\beta_3\theta_3 - \theta_2)/\beta_3 < 0$, the foreign government has no incentive to build a reputation with its private sector, but that the home government has an unambiguous incentive to pre-commit itself (as $W = W_{NC} \equiv \bar{c}\mu_{NC}/\theta_4 < W_L$).

6. Concluding remarks

The main objective of this paper was to investigate the case for coordination in the presence of a genuine long-run output-inflation trade-off when governments are able to pre-commit to their announced optimal policies. In a classical stock-flow model of interdependent economies, higher rates of monetary growth boost economic activity at home and abroad due to a two-country version of the Mundell–Tobin effect. Non-neutrality of government debt and liquidity constraints weaken the long-run output-inflation trade-off, since a higher rate of monetary growth means more revenues from the “inflation tax”, permits the servicing of a higher government debt and therefore the associated increase in private sector wealth increases consumption and leads to some crowding out of private sector investment. Since each country wishes to transfer the burden of higher inflation and the job of lowering the world real interest rate to the other country, competitive policies (whether in Nash or in Stackelberg equilibrium with pre-commitment *vis-à-vis* the private section) lead to two low inflation rates and to too low levels of capital, output and employment. Coordination leads to a lower world real interest rate and higher activity, but each country has an incentive to deviate by lowering its rate of monetary growth. These results suggest an international stale-mate in reducing the world real rate of interest.

However, if the governments are unable to pre-commit themselves due to the absence of binding contracts of reputational forces, the above results no longer hold. The problem is that the pre-commitment or “rules” outcomes are time inconsistent, since each government has an incentive to renege and levy a “surprise” inflation tax and thereby erode the real value of money balances accumulated by the private sector. The consistent or “discretionary” (“loss of leadership”) outcomes lead to excessive monetary growth rates, since neither government is able to manipulate the inflation rate and therefore they attempt to achieve the desired level of real activity exactly. It therefore does not matter whether governments coordinate or engage in competitive policy formulation and in both cases welfare is worse than under international policy coordination with pre-commitment. Hence, international policy coordination without pre-commitment yields the same welfare as competitive policy formulation without pre-commitment whilst pre-commitment without international cooperation does not pay.

Previous studies (e.g. Carlozzi and Taylor, 1985; Miller and Salmon, 1985; Currie and Levine, 1985; Oudiz and Sachs, 1985) did not allow for a long-run trade-off between output and inflation, hence the optimal plan is consistent once the steady state is reached and dynamic inconsistency is therefore a transient issue. However, when there is a long-run trade-off between activity and inflation, both the competitive and cooperative policies with pre-commitment are time inconsistent, even once the steady state has been reached. Clearly, time inconsistency is therefore a more persistent problem in models with long-run trade-offs. It should be pointed out that there may be a long-run role for international policy coordination in natural-rate-models when there are permanent shocks and both fiscal and policy instruments (e.g. Currie, Levine and Vidalis, 1987). In such models international cooperation without pre-commitment and pre-commitment without international cooperation do not necessarily pay (also see Rogoff, 1985; Miller and Salmon, 1985; Oudiz and Sachs, 1985; van der Ploeg, 1988). However, some argue that, when the game between the two governments and the private sector is treated as a sequential game, international policy coordination is a dominant and subgame-perfect strategy of the two Central Banks and therefore non-cooperation without pre-commitment is not a relevant outcome (Carraro and Giavazzi, 1988).

Although it requires a considerable stretch of the imagination, it may be useful to indulge in a brief empirical note. In the late sixties and early seventies the trust and cooperation between governments and private sectors that developed in the immediate post-war period broke down in most countries. This meant that governments could no longer make credible announcements about future monetary policy. The eventual result was the consistent solution with excessive inflation rates and too high levels of activity relative to the outcomes that would pertain under international policy coordination with pre-commitment. In the late seventies and eighties governments began to build a reputation for "sticking to their guns" (cf. Backus and Driffill, 1985). This meant that after some time pre-commitment outcomes became feasible. This resulted in a non-cooperation trap of much too low monetary growth rates and too low levels of real activity. It is not clear whether welfare is now lower or higher than in the early seventies, but it is clear that, now credibility has been achieved, there are large welfare gains from international policy coordination. The challenge is to persuade the major industrial countries to multilaterally increase their monetary growth rates, reduce the world real interest rate, increase world activity and increase welfare without damaging the reputations with the private sectors.

There are at least four interesting directions of future research. The first is to explore the issues discussed in this paper within the context of a model with proper micro foundations. The main difficulty will be to specify a satisfactory theory of the demand for money, but at least an explicit welfare analysis will be possible. It will be necessary to allow for time-varying rates of time preference and for finite horizons (Blanchard, 1985) in order to give a role for monetary policy (Marini and van der Ploeg, 1988). Finite lives are required, because when

agents are infinitely lived monetary policy is super-neutral (Sidrauski, 1967). The second direction is to properly allow for current-account dynamics (cf. Dornbusch and Fischer, 1980). The third is to relax the classical features of the model presented in this paper and to allow for Keynesian rigidities in wage and price formation (e.g. Taylor, 1979, 1980). This means that the levels of real liquidity become predetermined and are no longer forward-looking, so that there is an inflation-output trade-off even under credible policy formulation. In such a more general model, it is possible that, if governments cannot pre-commit, coordination can exacerbate the "credibility constraints" and therefore can be counter-productive and make both countries worse off (cf. Rogoff, 1985). It is also possible to allow for internal adjustment costs in investment decisions. This provides additional incentives to renege, for a government might announce a high monetary growth rate in order to depress the real interest rate and encourage investment. But once some capital has been accumulated, the government cheats and implements a lower monetary growth rate than promised. This renege goes in the opposite direction of the levy of a "surprise" inflation tax and can provide an additional reason why coordination might be counter-productive. The final direction is to extend the analysis to a model of three or more interdependent economies (e.g. Canzoneri and Henderson, 1986). If the two countries considered in this paper are the US and Europe, it is implicitly assumed that the individual countries that make up Europe cooperate and coordinate their policies. However, when the member states of Europe engage in competitive policy formulation and there are international externalities, the aggregate reaction curve of Europe differs. Cooperation within Europe may engender a deflationary response of the US, which can conceivably make coordination of European policies counter-productive.

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APPENDIX

Coordination

The cooperative strategies, when the governments can pre-commit themselves to their announcements about present and future policies, can be found from choosing μ and μ^* to minimise $W + W^*$, i.e. (5.6), subject to equations (4.6), (4.8), $k = k^* = \bar{k}$, $\pi = \beta_4 k^* - \beta_3(l^* + \frac{1}{2}l^d)$ and $\pi^* = \beta_4 k^* - \beta_3(l^* - \frac{1}{2}l^d)$. If the Hamiltonian is defined as

$$H \equiv \frac{1}{2}[\theta(k^* - \bar{k})^2 + \theta(k^* - \bar{k}^*)^2 + \{\beta_4 k^* - \beta_3(l^* + \frac{1}{2}l^d)\}^2 + \{\beta_4 k^* - \beta_3(l^* - \frac{1}{2}l^d)\}^2 + \lambda_1 \dot{k}^* + \lambda_2 \dot{l}^* + \lambda_3 \dot{l}^d], \quad (A1)$$

one obtains $H_\mu = \frac{1}{2}\lambda_2 + \lambda_3 = 0$, $H_{\mu^*} = \frac{1}{2}\lambda_2 - \lambda_3 = 0$.

$$\rho\lambda_1 - \dot{\lambda}_1 = H_{k^*} = \theta(k^* - \bar{k}) + \theta(k^* - \bar{k}^*) + \beta_4\{\beta_4 k^* - \beta_3(l^* + \frac{1}{2}l^d)\} + \beta_4\{\beta_4 k^* - \beta_3(l^* - \frac{1}{2}l^d)\} - \beta_1\lambda_1 - \beta_4\lambda_2, \quad \lambda_1(0) = \text{free} \quad (A2)$$

$$\rho\lambda_2 - \dot{\lambda}_2 = H_{l^*} = -\beta_3\{\beta_4 k^* - \beta_3(l^* + \frac{1}{2}l^d)\} - \beta_3\{\beta_4 k^* - \beta_3(l^* - \frac{1}{2}l^d)\} - \beta_2\lambda_1 + \beta_3\lambda_2, \quad \lambda_2(0) = 0, \quad (A3)$$

and

$$\begin{aligned} \rho\lambda_3 - \lambda_3 = H_\mu = & -\frac{1}{2}\beta_3\{\beta_4 k^* - \beta_5(l^* + \frac{1}{2}l^d)\} + \frac{1}{2}\beta_5\{\beta_4 k^* - \beta_5(l^* - \frac{1}{2}l^d)\} \\ & + \beta_5\lambda_3, \quad \lambda_3(0) = 0 \end{aligned} \quad (A4)$$

as the first-order conditions. Since l^* and l^d are forward-looking variables and unconstrained by their past history, their marginal contribution to welfare must be zero at the beginning of the planning horizon and consequently $\lambda_2(0) = \lambda_3(0) = 0$ (cf. Calvo, 1978). In fact, $H_\mu = H_{\mu^*} = 0$ yields $\lambda_2(t) = \lambda_3(t) = 0, \forall t \geq 0$. This implies that for cooperative strategies there is no multilateral incentive to re-optimize (renege), so that policy coordination is time consistent. (There is, of course, a unilateral incentive to deviate from the cooperative outcome). It follows from (A4) that $l^d(t) = 0, \forall t \geq 0$, so that $l = l^* = l^d$. (A3) gives $\pi = \pi^* = -\frac{1}{2}\beta_2\lambda_1/\beta_3$ and (4.8) gives $\mu = \mu^*$. Upon substitution of these results and (4.6) into (A2), one obtains, after some manipulation, the closed-loop representation of the optimal open-loop (pre-commitment) policies for $\rho = 0$:

$$\begin{aligned} \mu = \mu^* = & \beta_4 k^* - \beta_5 l^* + \frac{1}{2}(\beta_2/\beta_3^2)[(2\beta_4 - 1)(\beta_4 k^* - \beta_5 l^*) - \beta_4 k^* \\ & - \theta(k^* - \bar{k}) - \theta(k^* - \bar{k}^*)]. \end{aligned} \quad (A5)$$

Substitution of (A5) into (4.6) yields the closed-loop system:

$$\dot{k}^* = -\beta_1 k^* - \beta_2 l^*, \quad k^*(0) = k_0^* \quad (A6)$$

$$l^* = \frac{1}{2}(\beta_2/\beta_3^2)[(2\beta_4 - 1)(\beta_4 k^* - \beta_5 l^*) - \beta_4 k^* - \theta(k^* - \bar{k}) - \theta(k^* - \bar{k}^*)], \quad l^*(0) = \text{free}. \quad (A7)$$

The Jacobian of the system (A6)–(A7) has one stable and one unstable eigenvalue, $\pm \frac{1}{2}(\beta_2/\beta_3)\sqrt{1+4\theta}$, corresponding to the backward-looking variable, k^* , and the forward-looking variable, l^* , respectively. The steady state of this system yields $\mu = \mu^* = \pi = \pi^* = \theta(\bar{k} + \bar{k}^*)/(1+4\theta)$ (see (5.7) and (5.9)) and $k = k^* = 2\theta(\bar{k} + \bar{k}^*)/(1+4\theta)$. The movement along the stable manifold is given by

$$k(t) = k^*(t) = \exp(-\lambda t)k^*(0) + [1 - \exp(-\lambda t)]2\theta(\bar{k} + \bar{k}^*)/(1+4\theta) \quad (A8)$$

where the speed of adjustment, $\lambda \equiv \frac{1}{2}(\beta_2/\beta_3)\sqrt{1+4\theta}$, is an increasing function of the priority attached to the output target.

If the welfare loss criterion is, instead of (5.1), (5.12) and $\bar{c} = \bar{c}^*, \mu = \mu^* = \mu_C$ is given by (5.13), $\lambda_2(\infty) = 2\theta\beta_3\bar{c}/(1+\theta\beta_3^2) \geq 0$ and $\lambda_3(\infty) = 0$. If $\theta_3 \neq 0$, there is a multilateral incentive to renege as $\lambda_2(\infty) \neq 0$. Hence, with welfare loss functions that depend on the monetary growth rate, policy coordination with pre-commitment is time inconsistent. The "loss of leadership" solution (Buiter, 1983) sets $\lambda_2 = \lambda_3 = 0, \forall t \geq 0$ and therefore $\theta_1 y + \theta_2 l + \theta_3 \mu = \theta_1 y^* + \theta_2 l^* + \theta_3 \mu^* = \bar{c}, \forall t \geq 0$. Hence, in the steady state, $\mu = \mu^* = \mu_L \equiv \bar{c}/\theta_4$.

Competitive Nash equilibrium

The optimal policies with pre-commitment of the home country, given the optimal policies of the foreign country, may be found from choosing μ to minimize W , i.e. (5.1), subject to (4.6) and (4.8). One obtains $H_\mu = \frac{1}{2}v_2 + v_3 = 0$,

$$\begin{aligned} \rho v_1 - \dot{v}_1 = H_{k^*} = & \theta(k^* - \bar{k}) + \beta_4\{\beta_4 k^* - \beta_5(l^* + \frac{1}{2}l^d)\} - \beta_1 v_1 \\ & - \beta_4 v_2, \quad v_1(0) = \text{free}, \end{aligned} \quad (A9)$$

$$\rho v_2 - v_2 = H_l = -\beta_5\{\beta_4 k^* - \beta_5(l^* + \frac{1}{2}l^d)\} - \beta_2 v_1 + \beta_5 v_2, \quad v_2(0) = 0 \quad (A10)$$

and

$$\rho v_3 - \dot{v}_3 = H_\mu = -\frac{1}{2}\beta_5\{\beta_4 k^* - \beta_5(l^* + \frac{1}{2}l^d)\} + \beta_5 v_3, \quad v_3(0) = 0, \quad (A11)$$

where the home country's Hamiltonian is defined as

$$H \equiv \frac{1}{2}\theta(k^* - \bar{k})^2 + \frac{1}{2}\{\beta_4 k^* - \beta_5(l^* + \frac{1}{2}l^d)\}^2 + v_1 \dot{k}^* + v_2 l^* + v_3 \dot{l}^d. \quad (A12)$$

Similarly, for the foreign country one obtains $\frac{1}{2}v_2^* - v_3^* = 0$,

$$\begin{aligned} \rho v_1^* - \dot{v}_1^* &= \theta(k^* - \bar{K}^*) + \beta_4\{\beta_4 k^* - \beta_5(l^* - \frac{1}{2}l^d)\} - \beta_1 v_1^* \\ &\quad - \beta_4 v_2^*, \quad v_1^*(0) = \text{free}, \end{aligned} \quad (\text{A13})$$

$$\rho v_2^* - \dot{v}_2^* = -\beta_5\{\beta_4 k^* - \beta_5(l^* - \frac{1}{2}l^d)\} - \beta_2 v_1^* + \beta_3 v_2^*, \quad v_2^*(0) = 0 \quad (\text{A14})$$

and

$$\rho v_3^* - \dot{v}_3^* = \frac{1}{2}\beta_5\{\beta_4 k^* - \beta_5(l^* - \frac{1}{2}l^d)\} + \beta_3 v_2^*, \quad v_3^*(0) = 0. \quad (\text{A15})$$

Since there are 5 predetermined variables, i.e. k^* , v_2 , v_3 , v_2^* and v_3^* , and 4 jump variables, i.e. l^* , l^d , v_1 and v_1^* , the transient dynamics takes place on a 5-dimensional stable manifold. The steady state of this system for $\rho = 0$ satisfies from (4.6)–(4.8) $k^* = \mu + \mu^*$, $\pi = \mu$ and $\pi^* = \mu^*$, from (A9)–(A11), $\mu = \theta(\bar{K} - \mu^*)/(1 + \theta)$, and from (A13)–(A15), $\mu^* = \theta(\bar{K}^* - \mu)/(1 + \theta)$. Intersection of these asymptotic reaction curves, i.e. (5.2), yields the steady-state Nash equilibrium with pre-commitment, (5.3) or (5.10)–(5.11). The associated steady-state values of the co-states are $v_1 = -2\beta_5\mu_N/\beta_2 < 0$, $v_2 = -2v_3 = -\mu_N < 0$, $v_1^* = -2\beta_5\mu_N^*/\beta_2 < 0$ and $v_2^* = 2v_3^* = -\mu_N^* < 0$. Unless there are no distortions in the economies ($\bar{K} = \bar{K}^* = 0$), each government has an incentive to re-optimize (renege) and re-set the co-states of the forward-looking variables to zero as after time zero $v_2 \neq 0$, $v_3 \neq 0$, $v_2^* \neq 0$ and $v_3^* = 0$. This problem of time inconsistency means that the Nash equilibrium with pre-commitment is, in the absence of explicit or implicit binding contracts, not credible. The "loss of leadership" solution to the problem of time inconsistency (Buiter, 1983) treats the forward-looking variables as given, so that $v_2(t) = v_3(t) = v_2^*(t) = v_3^*(t) = 0$, $\forall t \geq 0$ and equations (A10), (A11), (A14) and (A15) are ignored. It is immediately clear from (4.6), (4.8), (A9) and (A13) that there are an infinite number of "loss of leadership" solutions (even if $\rho = 0$). Because the backward-looking laws of motion are independent of economic policy, the same indeterminacy occurs for the time-consistent solution proposed by Cohen and Michel (1984).

If the welfare loss criterion is (5.12) rather than (5.1), the pre-commitment outcomes are given by (5.14), $v_2(\infty) = v_2^*(\infty) = -\frac{1}{2}\mu_N - \theta(\theta_3 - \frac{1}{2}\theta_2\beta_5^{-1})(\bar{c} - \theta_4\mu_N) \neq 0$ and $v_3(\infty) = -v_3^*(\infty) = \frac{1}{2}\mu_N + \frac{1}{2}\theta\theta_2\beta_5^{-1}(\bar{c} - \theta_4\mu_N) > 0$ and are therefore time inconsistent. The "loss of leadership" solution sets $v_2 = v_3 = v_2^* = v_3^* = 0$, $\forall t \geq 0$ and therefore $\theta_1 k + \theta_2 l + \theta_3 \mu = \theta_1 k^* + \theta_2 l^* + \theta_3 \mu^* = \bar{c}$, $\forall t \geq 0$. The steady-state outcome is therefore $\mu = \mu^* = \mu_L \equiv \bar{c}/\theta_4$.

Competitive Stackelberg equilibrium

The optimal policies with pre-commitment of the Stackelberg leader may be found from choosing the time-trajectory for μ^* to minimise W^* subject to (4.6), (4.8), $v_2 = -2v_3$, (A9), (A10) and (A11). (A11) can be replaced by $2\beta_5\pi + \beta_2 v_1 = 0$. Hence, if the leader's Hamiltonian is defined as

$$\begin{aligned} H^* &\equiv \frac{1}{2}\theta(k^* - \bar{K})^2 + \frac{1}{2}\{\beta_4 k^* - \beta_5(l^* - \frac{1}{2}l^d)\}^2 + \omega_1 \dot{k}^* + \omega_2 l^* + \omega_3 l^d \\ &\quad + \omega_4 \dot{v}_1 + \omega_5 \dot{v}_2 + \omega_6 [2\beta_5\{\beta_4 k^* - \beta_5(l^* + \frac{1}{2}l^d)\} + \beta_2 v_1] \end{aligned} \quad (\text{A16})$$

one obtains $H_{\mu^*}^* = \frac{1}{2}\omega_2 - \omega_3 = 0$,

$$\begin{aligned} \rho\omega_1 - \dot{\omega}_1 &= H_{k^*}^* = \theta(k^* - \bar{K}) + \beta_4\{\beta_4 k^* - \beta_5(l^* - \frac{1}{2}l^d)\} - \beta_1\omega_1 - \beta_4\omega_2 \\ &\quad - (\theta + \beta_4^2)\omega_4 + \beta_4\beta_5\omega_5 + 2\beta_5^2\omega_6, \quad \omega_1(0) = \text{free}, \end{aligned} \quad (\text{A17})$$

$$\begin{aligned} \rho\omega_2 - \dot{\omega}_2 &= H_{l^*}^* = -\beta_5\{\beta_4 k^* - \beta_5(l^* - \frac{1}{2}l^d)\} - \beta_2\omega_1 + \beta_3\omega_2 + \beta_4\beta_5\omega_4 \\ &\quad - \beta_5^2\omega_5 - 2\beta_4\omega_6, \quad \omega_2(0) = 0, \end{aligned} \quad (\text{A18})$$

$$\begin{aligned} \rho\omega_3 - \dot{\omega}_3 &= H_{l^d}^* = \frac{1}{2}\beta_5\{\beta_4 k^* - \beta_5(l^* - \frac{1}{2}l^d)\} + \beta_3\omega_3 + \frac{1}{2}\beta_4\beta_5\omega_4 - \frac{1}{2}\beta_5^2\omega_5 \\ &\quad - \beta_4\beta_5\omega_6, \quad \omega_3(0) = 0, \end{aligned} \quad (\text{A19})$$

$$\rho\omega_4 - \dot{\omega}_4 = H_{v_1}^* = \beta_1\omega_4 + \beta_2\omega_5 + \beta_2\omega_6, \quad \omega_4(0) = 0 \quad (\text{A20})$$

and

$$\rho\omega_5 = \dot{\omega}_5 = H_v^* = \beta_4\omega_4 - \beta_5\omega_5, \quad \omega_5(0) = \text{free.} \quad (\text{A21})$$

The transient dynamics takes place on a 4-dimensional stable manifold associated with the predetermined variables k_4 , $v_2 (= -v_3)$, $\omega_2 (= \omega_3)$ and ω_4 . The steady state of this system can be shown to give $k = k^* = k_1$, $\mu = \mu_1$ and $\mu^* = \mu_1^*$ when $\rho \rightarrow 0$. The pre-commitment outcomes are time inconsistent, since v_2 , v_3 , ω_2 , ω_3 and ω_4 are non-zero after some time has elapsed.

REFERENCES

- AIZENMAN, J. and FRENKEL, J. A. (1985). "Optimal wage indexation, foreign exchange intervention and monetary policy". *American Economic Review*, 75, pp. 402–23.
- AOKI, M. (1981). *Dynamic Analysis of Open Economies*. Academic Press, New York.
- BACKUS, D. and DRIFFILL, J. (1985). "Inflation and reputation". *American Economic Review*, 75, pp. 530–8.
- BARRO, R. J. (1974). "Are government bonds net wealth?". *Journal of Political Economy*, 82, pp. 1095–117.
- BEGG, D. K. H. (1980). "Rational expectations and the non-neutrality of systematic monetary policy". *Review of Economic Studies*, 47, pp. 293–303.
- BLANCHARD, O. (1985). "Debts, deficits and finite horizons". *Journal of Political Economy*, 93, pp. 223–47.
- BUITER, W. H. (1981). "The superiority of contingent rules over fixed rules in models with rational expectations". *Economic Journal*, 91, pp. 647–70.
- BUITER, W. H. (1983). "Optimal and time-consistent policies in continuous time rational expectations models". LSE Econometrics Programme, London, Discussion Paper no. A39.
- BUITER, W. H. and EATON, J. (1985). "Policy decentralization and exchange rate management in interdependent economies", in J. S. Bhandari (ed.), *Exchange Rate Management under Uncertainty*. MIT Press.
- CALVO, G. A. (1978). "On the time consistency of optimal policy in a monetary economy". *Econometrica*, 46, pp. 1411–28.
- CANZONERI, M. B. and HENDERSON, D. W. (1986). "Three countries and coalitions". Chapter II of *Strategic Aspects of Macroeconomic Policy Making in Interdependent Economies*, mimeo.
- CARLOZZI, N. and TAYLOR, J. B. (1985). "International capital mobility and the coordination of monetary rules", in J. S. Bhandari (ed.), *Exchange Rate Management under Uncertainty*. MIT Press.
- CARRARO, C. and GIAVAZZI, F. (1988). "Can international policy coordination really be counter-productive?", Centre for Economic Policy Research, London, Discussion Paper no. 258.
- COHEN, D. and MICHEL, P. (1984). "How should control theory be used to calculate a time-consistent government policy?", *Review of Economic Studies*, 55, pp. 263–74.
- CURRIE, D. A. and LEVINE, P. L. (1985). "Macroeconomic policy design in an interdependent world", in W. H. Buiter and R. C. Marston (eds.), *International Economic Policy Coordination*. CUP, Cambridge.
- CURRIE, D., LEVINE, P. and VIDALIS, N. (1987). "International cooperation and reputation in an empirical two-bloc model", in R. C. Bryant and R. Portes (eds.), *Global Macroeconomics: Policy Conflict and Cooperation*, MacMillan, London.
- DORNBUSCH, R. and FISCHER, S. (1980). "Exchange rates and the current account". *American Economic Review*, 70, 5, pp. 960–71.
- FISCHER, S. (1979). "Anticipations and the non-neutrality of money". *Journal of Political Economy*, 87, 2, pp. 225–52.
- FISCHER, S. and MODIGLIANI, F. (1978). "Towards an understanding of the costs of inflation". *Weltwirtschaftliches Archiv*, IV, pp. 810–33.
- GALE, D. (1983). *Money: In Disequilibrium*. James Nisbet and CUP, Cambridge.

- MARINI, G. and VAN DER PLOEG, F. (1988). "Monetary and fiscal policy in an optimizing model with capital accumulation and finite lives". *Economic Journal*, 98, 392, pp. 772-86.
- MILLER, M. H. and SALMON, M. (1985). "Policy coordination and dynamic games", in W. H. Buiter and R. C. Marston (eds.), *International Economic Policy Coordination*, CUP, Cambridge.
- ODIZ, G. and SACHS, J. (1985). "International policy coordination in dynamic macroeconomic models", in W. H. Buiter and R. C. Marston (eds.), *International Economic Policy Coordination*, CUP, Cambridge.
- PLOEG, F. VAN DER (1988). "International policy coordination in interdependent monetary economies". *Journal of International Economics*, 25, 1/2, pp. 1-23.
- ROGOFF, K. (1985). "Can international monetary policy cooperation be counterproductive?". *Journal of International Economics*, 18, pp. 199-217.
- SIDRAUSKI, M. (1967). "Rational choice and patterns of growth in a monetary economy". *American Economic Review*, 62, pp. 534-44.
- TAYLOR, J. B. (1979). "Staggered wage setting in a macroeconomic model". *American Economic Review*, 69, pp. 108-13.
- TAYLOR, J. B. (1980). "Aggregate dynamics and staggered contracts". *Journal of Political Economy*, 88, pp. 1-23.
- TOBIN, J. (1965). "Money and economic growth". *Econometrica*, 33, pp. 671-84.

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- No. 1 G. Marini and F. van der Ploeg, Monetary and fiscal policy in an optimising model with capital accumulation and finite lives, The Economic Journal, Vol. 98, No. 392, 1988, pp. 772 - 786.
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- No. 23 J.R. Magnus and A.D. Woodland, On the maximum likelihood estimation of multivariate regression models containing serially correlated error components, International Economic Review, Vol. 29, No. 4, 1988, pp. 707 - 725.

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- No. 30 J.R. Magnus and A.D. Woodland, Separability and Aggregation, Economica, vol. 57, no. 226, 1990, pp. 239 - 247.
- No. 31 F. van der Ploeg, International interdependence and policy coordination in economies with real and nominal wage rigidity, Greek Economic Review, vol. 10, no. 1, June 1988, pp. 1 - 48.
- No. 32 E. van Damme, Signaling and forward induction in a market entry context, Operations Research Proceedings 1989, Berlin-Heidelberg: Springer-Verlag, 1990, pp. 45 - 59.
- No. 33 A.P. Barten, Toward a levels version of the Rotterdam and related demand systems, Contributions to Operations Research and Economics, Cambridge: MIT Press, 1989, pp. 441 - 465.
- No. 34 F. van der Ploeg, International coordination of monetary policies under alternative exchange-rate regimes, Advanced Lectures in Quantitative Economics, London-Orlando: Academic Press Ltd., 1990, pp. 91 - 121.
- No. 35 Th. van de Klundert, On socioeconomic causes of 'wait unemployment', European Economic Review, vol. 34, no. 5, 1990, pp. 1011 - 1022.
- No. 36 R.J.M. Alessie, A. Kapteyn, J.B. van Lochem and T.J. Wansbeek, Individual effects in utility consistent models of demand, in J. Hartog, G. Ridder and J. Theeuwes (eds.), Panel Data and Labor Market Studies, Amsterdam: Elsevier Science Publishers B.V. (North-Holland), 1990, pp. 253 - 278.
- No. 37 F. van der Ploeg, Capital accumulation, inflation and long-run conflict in international objectives, Oxford Economic Papers, vol. 42, no. 3, 1990, pp. 501 - 525.

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